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FIELD EXPERIMENTS.

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BULLETIN 224.

FIELD EXPERIMENTS.

REPORTED BY CHAS. D. WOODS.

The experimental work at Highmoor Farm is planned by the Director, the Biologists, the Plant Pathologist, and the Entomologist. In the following pages there are given the results of certain experiments that lie somewhat outside of the lines of work of any of the Station specialists. The carrying out of these experiments and the taking of the requisite notes devolved upon different members of the staff. In general the field work was executed under the direction of Mr. Wellington Sinclair, the Superintendent of Highmoor Farm. The notes were chiefly taken in 1910 and 1911 by Mr. Walter W. Bonas; in 1912 by Mr. George A. Yeaton, and in 1913 by Mr. Harold G. Gulliver.

TOP DRESSING EXPERIMENT ON GRASS IN 1910, 1911 AND 1912.

A fertilizer manufacturer who is an enthusiastic advocate of Thomas phosphate powder as an economical source of phosphoric acid that carries with it the lime needed to correct acidity of soil, asked that the Station undertake an experiment in top dressing grass land in which Thomas phosphate powder would be compared with acid phosphate as a source of phosphoric acid. The field best adapted to such an experiment on Highmoor Farm consisted of about five acres, half of which was seeded in 1909 and the other half in 1908. This was divided into three plots of one and three-fourths acres each in such a way that each plot contained an equal amount of each year's seeding. The grasses were a mixture of timothy and redtop with some clover and June grass. The stand was fair and about the same over the whole field. The plots ran north

and south. The middle plot was left unfertilized as a check plot. To the east plot there was applied each of the three years a mixture consisting of 100 pounds of nitrate of soda, 112 pounds of muriate of potash and 600 pounds of Thomas phosphate powder. To the west plot there was applied each of the three years 100 pounds of nitrate of soda, 112 pounds of muriate of potash and 600 pounds of acid phosphate. The results are given in the table which follows:

Table showing kinds and amounts of fertilizer used and yields per plot and per acre for each year and for the three years combined.

Plot.	KINDS AND AMOUNT FERTILIZER APPLIED EACH YEAR.	Year.	YIELD OF HAY.		
			Per plot.		Per acre.
			Pounds.	Tons.	Tons.
A	100 pounds nitrate of soda.....	1910	8560	4.28	2.45
	112 pounds muriate of potash.....	1911	3950	1.92	1.13
	600 pounds of acid phosphate.....	1912	5315	2.66	1.52
	Total.....			8.86	5.10
		1910	5625	2.81	1.60
B	No fertilizer.....	1911	2850	1.37	.81
		1912	3750	1.88	1.07
	Total.....			6.06	3.48
C	100 pounds nitrate of soda.....	1910	7135	3.57	2.04
	112 pounds muriate of soda.....	1911	3450	1.73	.98
	600 pounds Thomas phosphate powder.....	1912	5230	2.61	1.49
	Total.....			7.91	4.51

In 1910 there was an abundant rainfall in the grass growing months and the conditions were favorable for a heavy yield. In 1911 the conditions were the reverse and not enough water fell after the application of the fertilizer to render it very available to the grass plants. The conditions in 1912 were fairly favorable for a hay crop. But this was the fourth year for half of the field and the fifth year the other half had been in grass and cut for hay.

The surprising thing about this experiment is the increase due to the acid phosphate in 1910. Even if the increased yield from the Thomas phosphate plot be entirely ascribed to the muriate and nitrate the application of acid phosphate increased

the yield in 1910 about four-tenths of a ton per acre and in 1911 there was a small increase in yield over the plot to which Thomas phosphate powder was applied. In top dressing experiments* on the College farm no appreciable benefit was found from the use of phosphoric acid.

The fertilizer for plots A and C would cost in these amounts about \$8.50 for each of the three yearly applications or about \$25 for the three years for each fertilized plot. It would seem doubtful that on this particular land any advantage was derived from the addition of the Thomas phosphate powder other than maintaining the fertility of the soil. On this plot there was for the three years 1.85 tons of hay cut more than on the unfertilized plot. As the cost of applying the fertilizer was small and the extra labor in harvesting the crop not much increased because of this increased yield the extra hay was obtained on plot C at a cost of about \$13.50 per ton. On plot A the increased yield of 2.8 tons was obtained at a cost for fertilizer alone at the rate of a little less than \$9 per ton.

The Station practices top dressing its mowing lands at Highmoor Farm each year with a mixture of 100 pounds of nitrate of soda, 100 pounds of muriate of potash and 150 pounds of acid phosphate. This costs for the materials applied to the land about \$6 per acre. Such a mixture supplies more phosphoric acid than the crop of hay removes from the soil, about the same amount of potash as the crop of hay removes and about one-third to one-half of the nitrogen. It is doubtful if in average years more than 100 pounds of nitrate of soda can be applied without danger of loss from leaching.

Top dressing of mowing lands is profitable if the resulting increase in the hay crop is to be used and fed on the farm. At the price fixed in 1913 for the valuation of fertilizers at tide water in ton lots the fertilizing constituents of a ton of mixed hay are worth over \$7. To sell hay is to sell off from the farm fertilizing materials that will cost, including the carting of the hay to a shipping point, the purchase and application of fertilizers to make good those sold in the hay at least \$9 for every ton sold. Not to plan to replace the fertilizing constituents is to rob the farm of that amount of plant food.

*Bulletin 94, Maine Station.

HIGH RIDGE, MEDIUM RIDGE AND LEVEL CULTURE FOR POTATOES COMPARED.

EXPERIMENTS IN AROOSTOOK COUNTY.

The method of ridge culture is almost universally used by potato growers in Aroostook County. Probably over 90 per cent of the farmers practice what might be called extreme ridge culture. The ridging begins at the time of planting. The planter most used has a plow so constructed that it makes little more than a mark on the soil unless it is very light, instead of a furrow, then the disks at the rear of the machine cover the seed by throwing up a ridge perhaps 4 inches high so that the seed at the very start is practically on a level with the surface between the rows. A few farmers make a practice of going over the field with a weeder and somewhat flattening the ridge but the number that do this is comparatively few. The method most usually followed is to go between the rows with the cultivator perhaps 8 to 10 days after the potatoes are planted and then as soon as they begin to break the ground go over with the horse-hoe and bury them up also burying the weeds at the same time and thereby raising the height of the ridge. This kind of cultivation is continued until the tops are too large to pass through without injury. By this time an A shaped ridge has been formed about 12 to 15 inches high and, of course, the surface between the rows has been dropped by the continual scraping up of the soil so that the tubers growing in the ridge are considerably above the surface between the rows.

It can be readily seen that in a dry season a field so handled must suffer considerably from lack of moisture. In the rather wet seasons usual to Aroostook County no lack of moisture is felt and the drains between the rows are an advantage rather than an injury, but in an extremely dry season it would seem that the drainage is too great. The ridges being high and narrow dry out very quickly and it would appear therefore the crop must suffer more from lack of moisture than it would if the roots of the plant were below the level as they are when modified level culture is practiced.

In the years 1907, 1908 and 1909 field experiments comparing the shallow planting and high ridge cultivation common in Aroostook County with a deeper planting and a low broad ridge were carried out at Houlton. The three seasons had an abundant water supply. Indeed in 1909 there was more rainfall than the crop needed. Because of the long continued cold wet weather and early frost the yield was reduced materially. The results as given in the following table show no practical advantage of one method over the other so far as yield is concerned.

Table showing comparison of medium planted, broad low ridge with shallow planted high ridge in Aroostook County. Total area in experiments 15 acres.

METHOD OF CULTURE.	Year.	VARIETY.	Yield of merchantable potatoes per acre.
			Bush.
Medium planted.....	1907	Green Mountain.....	333
Medium ridge.....	1908	Green Mountain.....	301
	1909	Green Mountain.....	216
		Average three years.....	283
Shallow planted.....	1907	Green Mountain.....	325
High ridge.....	1908	Green Mountain.....	21
	1909	Green Mountain.....	204
		Average three years.....	273

EXPERIMENTS IN KENNEBEC COUNTY.

The successful growing of potatoes in Aroostook County has greatly stimulated the potato industry over the whole State. The great advance in value of land in Aroostook County has led farmers to sell and go to other parts of the State where land has less value. Both of these facts have led to the adoption of Aroostook County methods of potato growing all over the State. It seemed probable that the less rainfall and not infrequent drouths experienced in the more southern parts of the State might prove unfavorable to growing potatoes with the shallow planting high ridge method of cultivation. With the purchase of Highmoor Farm for the Station an experiment

comparing shallow planting with high ridge cultivation, somewhat deeper planting with a lower, broader ridge, and deep planting with as level cultivation as practicable, was begun. This has been continued through four years with two varieties of potatoes. The results of the experiment are here reported. The deep planted lots were planted at a depth of 5 inches, the medium at 3 1-2 inches and the shallow at 2 inches.

Full data as to the planting, cultivation, spraying and harvesting of the crop were kept each season. But in an experiment of this type it does not seem wise to use space in reporting details that, while they are important in showing that the crop was carefully grown, have little agricultural significance beyond that fact.

The season of 1910 was favorable for a maximum crop as the rainfall was ample and the growing season greatly prolonged by frost keeping off until October. The seasons of 1911 and 1912 were not so favorable and 1913 was particularly unfavorable, although the rainfall in August was greater than the average and saved the crop from the damage that threatened from the dry July.

The time required for planting was the same on all of the plots. The planting, spraying and harvesting were the same for all of the plots with the exception that on the deep planted it was necessary to use four horses on the digger. The deep planted required less hours of cultivation; the medium planted the most. A man and team for cultivating were on the deep plots 26 hours, on the medium 39 hours and on the shallow 35 hours per acre.

There was not much difference in the difficulties of digging between the shallow planted and the medium planted. The deep planted required four horses instead of two on the digger, and a good deal of care was necessary to be sure that the digger was sufficiently deep in the ground to prevent cutting the tubers.

The yields for the four years are given in the table which follows:

Table showing comparison of deep planted, level culture, medium planted, medium ridge and shallow planted high ridge at Highmoor Farm (Kennebec County). Total area in experiments 16 1-2 acres.

METHOD OF CULTURE.	Year.	VARIETY.	Yield per acre of merchant- able potatoes.
			Bush.
Deep planted.....	1910	Green Mountain.....	365
Level culture.....	1911	Irish Cobbler.....	16
	1912	Irish Cobbler.....	156
	1913	Green Mountain.....	359
		Average Green Mountain.....	360
		Average Irish Cobbler.....	163
		Average four years.....	261
Medium planted.....	1910	Green Mountain.....	436
Medium ridge.....	1911	Irish Cobbler.....	170
	1912	Irish Cobbler.....	162
	1913	Green Mountain.....	334
		Average Green Mountain.....	385
		Average Irish Cobbler.....	166
		Average four years.....	276
Shallow planted.....	1910	Green Mountain.....	372
High ridge.....	1911	Irish Cobbler.....	130
	1912	Irish Cobbler.....	147
	1913	Green Mountain.....	277
		Average Green Mountain.....	325
		Average Irish Cobbler.....	139
		Average four years.....	232

CONCLUSIONS.

In the three years experiments comparing the usual method practiced in Aroostook County with deeper planted seed and a lower, broader ridge than is commonly used there showed that so far as yield was concerned there is nothing to chose in that locality between the two methods.

The deep planted and medium planted gave practically the same yields at Highmoor Farm with the advantage (though within experimental error) in favor of the medium planted. The medium planted and medium ridge gave considerably better yields at Highmoor Farm than the shallow planted and high ridge. The medium ridge is cultivated as cheaply as the shallow ridge and is harvested nearly as easily. The deep planted are cultivated at less cost than either of the two other methods but are far more difficult to harvest.

The results indicate that for Aroostook County the shallow planted high ridge is well suited to the climatic conditions. And they also clearly indicate that for the lower counties in the State with their lesser rainfall during the growing season the medium planted with the broad low ridge cultivation is preferable to either of the others.

SOY BEANS FOR FODDER, SILAGE AND SEED.

In 1903 and 1904 the Station grew on the college farm at Orono several varieties of soy beans. These were grown for forage and for silage. The results were published in Bulletin 106 and made up part of the Report of the Station for 1904. The bulletin is out of print and there are very few available copies of the Report.

The soy bean carries a high percentage of oil which has very good drying qualities and on this account has attracted the attention of paint manufacturers. The Paint Manufacturers' Association of the United States have been growing in coöperation with people through the northern belt of states certain varieties of soy beans for seed with the idea of learning the yield and the amount and quality of oil yielded under different climatic conditions. Although it is not at all likely that the soy bean can ever be grown as a profitable seed crop in Maine, three varieties were grown in coöperation with the above named Association at Highmoor Farm in 1913.

As the earlier report on soy beans at this Station is out of print the earlier as well as the later experiments are here briefly given.

The soy bean was introduced into the United States several years ago from Japan, where it is grown for human food. In this country it has chiefly been grown as a forage crop, and as it thrives best in a moderately warm climate is better known in the southern and middle than in the northern states. Some of the earlier varieties, however, will mature seed in New England. At the Massachusetts and Storrs (Conn.) Experiment Stations a few varieties have been grown quite successfully for soiling crops, for silage by itself or mixed with corn, and for the seeds.

The soy bean is an erect, annual plant, with branching, hairy stem, trifoliate, more or less hairy leaves, rather inconspicuous pale lilac or violet colored flowers, and broad, two to five-seeded pods, covered like the stem, with stiff, reddish hairs, The seeds vary in color from whitish and yellowish to green, brown and black; and in shape from spherical to elliptical and more or less compressed.

The seeds are self pollinated, and on this account are sure to produce seeds wherever the plants reach maturity.

CONDITIONS OF GROWTH.

It is believed in Japan that in northern climates, soils of a rather strong character are best adapted to the soy bean. It is usually sown about the end of May, and when used for hay is cut early in August. In both Europe and America it has been found to thrive best on soils of medium texture that are well supplied with potash, phosphoric acid, and lime. It succeeds very well, however, on comparatively light soils, often giving an abundant crop on soils too poor to grow clover.

The soy bean requires about the same temperature as corn. Professor Brooks says that the earlier sorts will mature in Massachusetts with as much certainty as will the earlier varieties of corn.

As a general thing, the soy bean is not so easily injured by frost as the common field or garden varieties of beans, and hence it can be planted earlier in the spring and can also be left in the field later in the autumn.

FERTILIZING AND CULTURE.

Like all leguminous plants, the soy bean, through the aid of root tubercle organisms, acquires atmospheric nitrogen. When the soy bean was first introduced into America it did not form root tubercles. In order to insure the growth of the root tubercles it is necessary to use seed that has been inoculated, or to inoculate the soil with the proper organism. This last is readily done by applying broadcast a small amount of soil taken from a field where soy beans developing root tubercles have been grown. At this Station no tubercles formed on

plants grown in soil that had not been inoculated, but they grew abundantly where soil from infested soy bean was applied at the rate of a few barrels to the acre. According to our experience the beans will grow as well without the root tubercles as with, provided they are liberally fertilized. Their economical growth depends upon the presence of the root tubercles, as in this way they can be grown with little or no nitrogen in the fertilizer. If they are to be grown on soil containing no root tubercle organisms, they require a fairly liberal application of a complete fertilizer. If grown in good soil where root tubercles may be expected to develop, only phosphoric acid and potash need be supplied in the fertilizer. The soil should be prepared as for ordinary beans. It should be made fine, free from clods and lumps, and smooth. A good seed bed is essential to a good growth.

In this climate the soy bean should be planted a little earlier than ordinary beans, but not until the ground has warmed up considerably. The first season we planted in drills 3 feet apart. This was too far apart for the best yield. Nearly double the yield per acre is obtained when the drills are 16 inches apart. In the case of the wide drills it was necessary to cultivate three times with the horse cultivator. With the drills 16 inches apart they were cultivated once with a hand wheel hoe. On fairly clean land good success may be had with broadcasting or still better by the use of the grain drill. If planted in rows, the seed should be sown with a hand seed drill similar to that used for beets or turnips. It will require about 3 pecks of seed per acre of the medium green soy bean when seeded in drills 16 inches apart. If the seed is broadcast, a bushel will be none too much for an acre. It will probably not be wise to attempt to grow soy beans in Maine for the seed, but if this is done, the drills should be at least 18 inches apart and the soil should be kept stirred and clean, as in the case of ordinary field beans. If wanted for silage, the beans can be grown alone or planted with corn. The latter method is quite strongly recommended, the seeds being mixed and put in the planter in the proportion of 10 quarts of corn to 7 of beans. The forage from this mixture can be fed green or cut for the silo.

YIELD OF GREEN FODDER.

The yield of green fodder that can be had in Maine will probably vary from 5 to 10 tons per acre. In the large plots grown by this Station in 1903 the largest yield was only a little over 5 tons to the acre. But the rows were twice too far apart, having been planted in drills 3 feet apart. If they had been planted at the same distance as the small plots in 1904 (16 inches) there is no reason for thinking the yield would not have been nearly or quite doubled, for at no time did the plants come near filling the space between the rows. On good land, with fair cultivation and average season, a yield of 8 tons of green fodder could doubtless be counted upon. Cured into hay this would give a yield of about 2 1-2 tons per acre.

NUTRIENTS IN SOY BEAN AND THEIR DIGESTIBILITY.

The composition of the soy bean as compared with other legumes stands high. The fodder closely resembles clover in composition. Soy bean silage, in both composition and digestibility, is the equal of clover silage. It is doubtful if any more digestible nutrients can be grown from an acre with soy beans than with clover. But in some localities they are a surer crop and need only a single season for their growth. Soy beans would be more naturally compared in this State with corn, for if grown at all they seem best adapted for silage. The chief difference between corn and soy bean is found in the high protein content of the latter. Like other beans it has the power of taking its nitrogen to form protein from the air, and since it is richer in protein than corn, it may be justly considered a desirable addition to the list of forage plants. As the price of feeds rich in protein is advancing it seems very desirable that as many legumes (plants rich in protein) that can gather their own nitrogen from the air be grown as possible.

SOY BEAN SILAGE.

The soy bean plants dried do not make desirable forage as the cured stalks are rather coarse and hard, and are there-

fore best fed green or made into silage. Like most leguminous plants, soy beans do not keep as well in the silo alone as when mixed with corn. Consequently, in the trials made at the Maine Station, the beans were cut and put into the silo with corn. The proportion in this case, for convenience, was about 14 of corn to 9 of beans. The silage kept perfectly and when fed out was nearly as green as when it went into the silo. The animals ate it with great relish and the sheep preferred it to clear corn silage.

YIELD OF DRY MATTER AND PROTEIN.

Soy Bean vs. Corn Fodder.

The average yield for 7 seasons at the Maine Station of fodder from corn of Sanford or similar variety that will not mature in this climate was a little over 17 tons per acre. For the same period the average yield of green fodder from matured corn was a little over 11 tons per acre. The same season that the Massachusetts Station obtained a yield of 16 tons of Longfellow corn they harvested 10 tons of soy bean fodder from one acre. If we assume an average yield of soy bean fodder at 8 tons and corn fodder at 12 tons per acre, and use in calculation the average of the 13 analyses of each material the soy bean would yield 3,560 pounds of dry matter and the corn 5,064 pounds. The soy bean would contain 576 pounds of protein and the corn 552 pounds.

It would, therefore, appear that a crop of corn will give practically as many pounds of protein as a crop of soy bean, and over 40 per cent more dry matter. Furthermore, the nutrients of the corn are more digestible than those of soy beans. The corn is probably a surer crop, but on the other hand it requires a fertilizer carrying more nitrogen (costing from \$10 to \$15 per acre) to grow the corn and it is necessary to handle 50 per cent more material to obtain the same weight of protein.

SOY BEANS FOR SEED.

Three varieties of seed furnished by the Paint Manufacturers' Association were tried at Highmoor Farm in 1913.

Soy bean A was a variety imported from Manchuria and supposed to carry an oil of high oxidizing properties. This variety was successfully grown in several states in 1912, and that year they found marked differences between the percentages of oil in beans grown in New Jersey and in Kentucky. The bean in North Dakota was practically the same as that in Kentucky. Variety 1002 was an American type which was stated not to mature as quickly as A. No description was furnished with Soy Bean 302, the other variety. They were all tested for germination and found to germinate well.

The soil in which they were grown was a medium sandy loam in excellent heart and tilth. It was prepared by plowing and harrowing and the application of a barrel of soil furnished by the Massachusetts Agricultural Experiment Station from a field where soy beans with the root nodules had been successfully grown the preceding year. This inoculation proved successful for all the plants examined were found to bear root nodules in abundance. There were also put on 500 pounds of a high grade fertilizer carrying 4 per cent nitrogen, 8 per cent available phosphoric acid and 7 per cent potash. It is probable that a fertilizer carrying much less nitrogen could have been equally as well used. As it was desired to give the plants every opportunity for growth a fertilizer carrying sufficient nitrogen to mature the crop was applied. They were sown in drills June 7, the rows being three feet apart. June 17 all three varieties were up. July 7, thirty days from the time of planting, the stand was good on all three of the plots, but thought to be too thick on 302 and 1002. Plants on 302 were 6 inches high; on 1002, 4 to 5 inches high; and on plot A 3 to 4 inches high.

August 5, sixty days from planting, the soy bean A plants were 10 inches high; 1002, 14 inches; and 302, 14.5 inches. Every 3 feet of row there were 8 soy bean plants A, 19 soy bean 1002, and 20 soy bean 302. No disease or insect pests, and all three plots were showing vigorous growth.

August 11 soy bean A was in blossom. August 13, 302 was in blossom. August 18, 1002 was in bloom.

September 5, 90 days from planting, soy bean A was 23 inches high and in good vigor, seed pods numerous with an average length of nearly two inches. The beans averaged three

to the pod. Soy bean 1002 plants averaged 33.5 inches high, in good vigor, uniform, very few seed pods, but were still blooming vigorously. Soy bean 302 was 25 inches high with excellent vigor, quite uniform, seed pods numerous with an average length of two inches, with three beans to the pod. This variety stopped blooming and is much earlier than either of the two others.

September 15 the lower part of the field was touched by frost. October 10 soy beans A and 302 were harvested by pulling the plants. 1002 did not mature seed and was cut for fodder.

At threshing soy bean 302 yielded at the rate of 650 pounds per acre, and soy bean A at the rate of 700 pounds of shelled beans per acre. The beans were planted in rows three feet apart at the suggestion of the Paint Manufacturers' Association. This was too far apart for the two varieties that matured for a maximum yield. As found in the earlier trials, 18 inches would have been a better distance between rows. At that distance the yield would have been 75 per cent greater without doubt or a yield of 20 bushels of beans. Such a yield would carry as much protein and as much oil as 70 bushels of corn but only an eighth as much carbohydrates. While the threshed vines are readily eaten by stock they do not carry anything like as much digestible matter as the stover from 70 bushels of corn. The crop is easier handled, however, costs much less for fertilizer needed and is a soil restorer.

SUMMARY.

From the trials made at the Maine Station and those at other New England Stations the following summary is justified:

Soy beans can be grown in parts of Maine where corn thrives.

Where early corn matures, the early white soy bean will usually mature.

Where Sanford corn ears, the early medium soy bean will form pods.

Soy bean can be grown with less nitrogen than corn.

In order to grow the soy bean most economically, the soil should be inoculated with the organism that forms root tubercles.

The soil should be prepared as for corn or beans and should be free from lumps and clods.

Fertilizers carrying phosphoric acid and potash are essential and on good land no nitrogen is needed if the soil is inoculated for root tubercles.

Sown in drills 16 inches apart, about 3 pecks of seed is needed per acre. If drilled with a grain drill or sown broadcast more seed, perhaps a bushel per acre, will be needed.

Soy beans can be grown with corn, mixing the seed at the rate of 10 quarts of corn and 7 of soy beans. Thus seeded the drills should be about 3 feet apart.

When sown in drills they should be cultivated the same as common beans. In case of narrow spaces between drills, a hand wheel hoe does the work rapidly and well.

It is doubtful if it would be profitable to grow soy beans for seed in Maine. The varieties that will ripen seed in this climate make small vine growth.

The crop is best adapted for feeding green or for silage.

The crop can be harvested by hand or machine. For silage a grain reaper and binder leaves it convenient for handling and for the silage cutter.

A yield of 8 tons of green crop is an average in average seasons on average soil.

Eight tons of soy bean fodder carries about the same amount of protein as 12 tons of corn in milk ready for the silo, but it carries only a little more dry matter than 8 tons of corn.

If grown with corn, it can be cut with the corn, by hand or a corn harvester.

When grown by itself for silage, it is best mixed with corn at time of cutting into the silo. About 3 parts corn to 2 parts beans is a very good proportion.

Less protein (the most expensive part of commercial feeding stuffs) need be fed with soy bean and corn silage than with corn silage alone.

SPRAYING WITH SULPHATE OF IRON SOLUTION TO CONTROL WILD MUSTARD IN GRAIN AND OTHER SOWN CROPS.

There are three quite closely related plants of the mustard family that are troublesome weeds, particularly in sown crops,

all over the eastern part of the United States and in Europe, from whence they were brought in as weeds.

These three plants are *Sinapis arvensis*, which is the common charlock or wild mustard. It is very abundant in Maine. The *Raphanus raphanistrum*, or wild radish, jointed or white charlock, is also very abundant and a persistent weed. The third, wild turnip, *Brassica tempestris*, is not so bad a weed as the other two as it rarely lasts in the land more than one or two years. These all belong to the mustard family and more or less resemble each other in their appearance. Wild turnip has a smooth leaf and stem, while both the wild radish and the wild mustard are roughened with strong hairs. It is not easy to distinguish between wild radish and wild mustard when the plants are young. The wild radish leaves, however, are much more deeply cut, the divisions between the lobes of the leaves reaching nearly to the midrib. With a small magnifying glass the stem hairs make it easier also to distinguish. Those of the wild mustard generally protrude at right angles from the stem while those of the wild radish slant downward. Wild mustard has a straight, jointless seed pod which splits open when dry and scatters its seed at the slightest touch. On wild radish the seed pod is jointed and tends to break up in segments when dry.

A somewhat superficial examination of fields indicates that perhaps 75 per cent of the oat and barley acreage in Maine is infested with "wild mustard", and that 50 per cent is so badly infested that hand pulling cannot be resorted to with profit.

In experiments which were conducted in Germany it was found that in some instances the crop was diminished so that when it was grown with the mustard there was a yield of only one-third of what was grown on the same kind of land under the same conditions where the mustard had been removed.

It has been found absolutely impossible to separate wild radish or mustard segments or seed from oats or barley by even the most improved types of fanning mills, or by floating in water. As a result, if these weeds are permitted to mature and are harvested with the grain crops, it means again seeding the fields with these weeds, or else purchasing seed grain from outside distributors. The cost of good seed oats free from weed seeds is well known. Many farmers to be relieved of

this burden of buying seed oats, purchase ordinary feed oats, which as a rule are loaded with mustard seed. Thus the farmer who buys cheap seed oats encounters weed seeds in both harvesting his crop and in seeding his land.

Extensive studies have been made of this plant and methods of control in France and in Germany, particularly under the auspices of the German Agricultural Society by Gustav Schultz.

Using this work of Schultz as a basis in the years 1905 to 1908 inclusive the Maine Agricultural Experiment Station carried on extensive experiments in an endeavor to kill wild mustard in sown grain crops by spraying with iron sulphate and copper sulphate. It was found that it was perfectly possible by spraying with iron sulphate to rid the field of wild mustard at a moderate cost.

Experiments on wild radish were not so successful. Both French and German experimentors, however, claim to have killed wild radish by a 20 per cent solution of iron sulphate. In their published results, however, they use the common names and rarely distinguish between the wild radish and the wild mustard in their field experiments.

In 1912 further trials were made by this Station upon wild radish and wild turnip. It was found possible to completely exterminate wild turnip by spraying with sulphate of iron even after the plants had obtained their sixth leaf. With wild radish the plant was controlled by spraying when it had only shown its fourth leaf. The results of these experiments indicate that it is perfectly possible to handle, without injury to the grain crop, wild mustard, wild radish and wild turnip wherever they infest grain fields. While a single spraying may not kill every plant it will so reduce the number that by a small amount of work in hand pulling it will be easily possible to free a grain field absolutely from these pests.

One of the experiments in 1912 was carried on on a farm where in 1911 practically 25 per cent of the threshed yield was mustard seed. In this particular instance it was chiefly the wild turnip. In an experiment on this farm where the wild turnip was slow in starting so that the oats were well above it, a single spraying applied when the wild turnip plants were in the sixth leaf resulted in killing most of them, and where two sprayings were applied, (the second three days later, at which

time the plants had developed eight leaves,) the field was entirely freed from this pest despite the fact that the oats were so tall that they partially covered the wild turnip plants, and that the plants were far larger than they should be for treatment.

It is rarely that a field is badly infested with more than one of these varieties. If it is the wild mustard or the wild turnip it can be more readily controlled than the wild radish. However, all three of the plants can be controlled by spraying with iron sulphate at the proper time and under proper conditions.

IDEAL CONDITIONS.

While it is not always possible by any means to spray at exactly the right time and under exactly the right conditions the following are the points to be aimed at:

It is of the utmost importance to spray the plants while they are small and before the buds form. They should not be in more than the third or fourth leaf, for if they are much larger than that there is danger that the plants will not be killed but only injured by the spray. The plants should be so small that they can be completely covered by an ordinary drinking tumbler.

There should be used common iron sulphate and water. Dissolve so as to make a 17 to 20 per cent solution. The solution is made by suspending 100 pounds of the iron sulphate in the top of a barrel containing 50 gallons of water. If allowed to stand over night the major portion of the iron sulphate will be dissolved and only a small amount of labor is needed in the morning to complete the solution. This solution will have a strength of about 22 per cent, and for use should be reduced by the addition of about 20 gallons of water to make the solution contain about 17 per cent of iron sulphate.

The solution must be applied as a very fine mist. Sprinkling will not suffice. An ordinary potato sprayer which can develop power sufficient to maintain a pressure of 60 to 70 pounds to the square inch, by the use of fine nozzles, will make the desired mist.

The plants should be sprayed after the dew has dried off in a still air and on a bright sunny day. It is not usually possible

to find all of these conditions. The most important thing is to spray the plants when they are of the proper size, before they get too large.

It is to be hoped that the growers of small grains that are troubled with "charlock" (whether it be wild mustard, wild radish or wild turnip) will keep this matter in mind and provide a supply of iron sulphate. The materials must be provided amply in advance; a day or two days delay may make all the difference in the world with the results of the application. The materials are applied with an ordinary spray pump, such as is used in spraying potatoes. A fine nozzle must be used and the pressure to 60 to 80 pounds to the square inch in order to develop a fine mist. Sprinkling the plants will not kill them. The material must fall upon the plants in the form of a fine mist and the spraying should be done after the dew has dried from the plants, and best on a bright day when there is no wind. Application must be made before the plants have developed beyond the fourth leaf. At this stage the plant is so small that it can be covered by an ordinary drinking tumbler.

Condensed Directions. Dissolve 100 pounds iron sulphate in 70 gallons of water, or 70 in 50 gallons, as is most convenient. Apply at the rate of about 70 gallons per acre. Use a powerful pump and have the pressure at least 60 pounds. Use a fine nozzle. This should develop a fine dust-like mist. A coarse mist will not do. Spray after the dew has dried off when the plants are in the fourth leaf. Choose if possible a bright, warm day without wind. But spray when the plants are the proper size even if the day is not all that could be desired. If the field is badly infested or the conditions of the first spraying were not satisfactory, a second spraying three days later is desirable. Later go over the field and pull by hand any plants that may have escaped.

EFFECT OF IRON SULPHATE SPRAY UPON POTATOES.

Because of urging growers to spray for wild mustard in oats, the writer was in the spring of 1913 the recipient of quite a number of letters of inquiry as to whether wild mustard could not be controlled in potatoes by spraying with sulphate of iron solution. The reply was sent that the treatment would kill

the mustard and probably would seriously injure the potatoes as well.

In order to ascertain the effect of spraying potato plants with sulphate of iron one plot each of Irish Cobbler and Green Mountain potatoes were planted on June 10, 1913. Each plot contained four rows of about 250 feet in length.

Other than the spraying with sulphate of iron the treatment of these potatoes was in every way the same as that of other potatoes grown in 1913. The land was prepared by plowing and harrowing to make a good seed bed. Medium sized, healthy, sound tubers were used for seed. The seed was treated with formaldehyde for fungi. Fertilizer at the rate of 1700 pounds per acre, carrying 4 per cent nitrogen, 8 per cent available phosphoric acid and 7 per cent potash, was applied at planting and at first cultivation.

The plants appeared July 2 and three days later the soil was hilled around them. On July 8 the plants were 2 to 4 inches above ground. Although there were no plants of either kind of mustard on the plots they were sprayed twice on July 8 with a solution of 100 pounds of iron sulphate in 50 gallons of water. In 24 hours all the tissue that had been hit by the spray had turned black. These blackened portions of the leaf surface later shrivelled and were brown. No plants were completely killed.

On July 10 a sulky cultivator was used, straddling each row. On July 12 the plants had recovered somewhat and were growing. The tops were sprayed for the second time July 14. But one application was made this time. This spraying had the same effect as the first except that the plants did not seem to recover as rapidly. Five days later, however, the tops showed signs of recovering. On July 25 the field was cultivated and sprayed with bordeaux mixture and Arsenoid. On July 30 hardly any trace of the spray injury was visible.

The plants started blossoming August 4, 20 days later than other potatoes of the same variety planted on the same date. On August 13 the tops were from 12 to 16 inches in height and still blossoming. At this time, compared with other Irish Cobblers and Green Mountains planted at the same date, the tops and tubers were smaller and the period of blossoming later.

September 10 the Irish Cobblers had "turned" and were fallen down. The Green Mountains were still vigorous. The flea beetles were numerous. On September 14 the lower part of the field went down with the frost. On September 15 the Irish Cobblers were all dead and on September 28 they were dug. On October 13 the Green Mountains were harvested.

THE YIELDS.

Irish Cobblers. 1070 feet of row yielded 1000 pounds of tubers. This is at the rate of 15,430 pounds per acre or 257 bushels. Compared with other Irish Cobblers, the tubers were almost three times as large, many weighing two pounds. The average yield of other Cobblers in a formaldehyde experiment was 220 bushels per acre, and in a general spraying experiment Cobblers yielded at the rate of 150 bushels per acre.

Green Mountains. 1164 feet of row yielded 1760 pounds of tubers at the rate of 24,968 pounds, or 416 bushels per acre. The average yield of other Green Mountains in a culture experiment was 303 bushels per acre.

CONCLUSIONS.

That wild mustard if it had been present would have been killed by these three applications of iron sulphate admits of little doubt.

The effect of the iron sulphate upon the potato tops was quite similar to that of a hard freeze. They recovered in much the same way as frosted vines do.

That the increased yield was due to the treatment there is little doubt. But it does not follow that similar results would happen in different seasons under other climatic conditions.

The temporary checking of a tuber forming plant may have stimulated tuber growth. It is a common belief that too great a development of vine interferes with tuber setting. That the increased yield was fortuitous seems to be the more plausible explanation. The experiment will be repeated on a larger and more thorough scale at Aroostook Farm in 1914.

The experience indicates that with a field of potatoes badly infested with mustard spraying with sulphate of iron solution may be resorted to with a reasonable expectation that the yield

of tubers will not be diminished. At present such a treatment can only be recommended as a rather extreme measure.

ANALYSES FOR POISON OF APPLES SPRAYED WITH ARSENATE OF LEAD IN MID-SUMMER.

The brown-tail moth flight in July 1913 was in the vicinity of Highmoor Farm the heaviest that has been known. Though all of the brown-tail moth nests were removed from the orchards at Highmoor Farm in the winter of 1912-13, hundreds, if not thousands, of nests must have been left in that vicinity. The removal of brown-tail moth nests by picking is laborious and expensive. It was, therefore, decided to thoroughly spray the orchards after the female brown-tail moths had deposited their eggs and at about the time when these eggs would be hatching. Therefore, all of the trees in the orchard were thoroughly sprayed with arsenate of lead the first week in August, 1913. The result, so far as the control of the brown-tail moth was concerned, was a success, for in the winter of 1913-14 the orchards were free from brown-tail moth nests, while all the unsprayed orchards in that vicinity, as well as the many trees along the roadside, are literally covered with the nests.

It was with some trepidation as to the effect upon the crop that arsenate of lead was applied so liberally when the apples were a third grown. Arsenate of lead is a double dangerous poison, not only because it contains arsenic but it also carries lead which is a so-called cumulative poison.

Therefore, at the time of harvest ten different lots of apples, aggregating about two barrels of three different varieties, that had been heavily sprayed, were picked and sent to the laboratory. Care was taken in picking and handling so that any arsenate of lead which might be clinging to the apples should not be removed. The apples in the ten lots were thoroughly and carefully washed in water at the laboratory and all of the washings saved. These were evaporated to the smallest amounts possible and the organic matter removed. The determinations of both the lead and the arsenic were made in the washings from each lot, and the amounts of lead arsenate present were calculated both from the lead found and from the

arsenic found. Theoretically the amount of arsenate of lead should be exactly the same when calculated from the arsenic as when calculated from the lead. It will be noted, however, that the arsenic found was considerable in excess of the lead needed to make arsenate of lead. In other words the arsenate of lead calculated from the arsenic found is a half more than that calculated from the lead found. No explanation of this discrepancy is offered. The chemical work was carefully checked. It is a matter of no practical importance but it has occupied the attention of quite a bit of the time of the chemists.

In order to make sure that all of the arsenic was removed by this washing in the laboratory samples of the washed peelings from two different lots were examined and the results show that they were entirely free from arsenic and, therefore, all of the arsenate of lead was removed by washing. The results of the analyses are given in the following table:

Table showing results of analyses of apples sprayed with arsenate of lead.

Sta. No.	VARIETY OF APPLE.	Number apples tested.		Amount arsenic oxide found.	Amount metallic lead found.	Arsenate of lead per apple calcu- lated from arsenic lead.	
		Number	Weight grams.	Mgr.	Mgr.	Mgr.	Mgr.
11644	Baldwin.....	43	4600	4.305	8.673	.454	.292
11645	"	45	5600	3.690	7.853	.372	.252
11646	"	49	7100	3.690	7.853	.342	.232
11638	Ben Davis.....	47	5900	2.153	3.722	.208	.114
11639	" "	50	6850	2.460	5.600	.233	.162
11640	" "	45	6700	1.535	3.381	.140	.108
11641	" "	47	5450	2.460	5.258	.238	.162
11642	" "	47	7000	4.610	8.330	.445	.255
11643	" "	47	5650	4.305	8.673	.416	.267
11637	Russets.....	45	4100	2.460	4.917	.245	.155

Arsenic in the form of arsenious oxide is frequently administered as a tonic. The maximum dose is five milligrams and is continued at the rate of not to exceed ten milligrams per day. The washings from about ten pounds of apples carry at

the most four milligrams of arsenic in the form of arsenic oxide. If any of these summer sprayed apples had been eaten without wiping the parings in any way it would have taken about half a bushel a day to get the maximum medicinal dose. Hence any danger from the eating of sprayed apples from the arsenical standpoint is a negligible quantity. Paring the apple would exclude all of the arsenic which it carries, and ordinary wiping of the apple would remove practically all of it from the skin. The poison does not penetrate below the skin and is easily wiped off or washed off.

Lead under some circumstances is a dangerous poison. It is one of the so-called cumulative poisons. This simply means that if one is constantly exposed to the poison, as a painter or manufacturer of arsenate of lead might be, the lead might be absorbed by the system faster than eliminated and this would result in a case of so-called lead poisoning. Lead, however, is not a cumulative poison in the sense that it is not eliminated from the body, but it is more slowly eliminated than many other poisonous materials.

The amount of lead arsenate carried upon these apples tested 60 days or longer after spraying varied from an eighth to a third of a milligram. This amount is insignificant and no harm could come from the continued use of apples carrying this amount of arsenate if no precautions were taken whatever in removing it from the skin if the parings themselves were eaten. Washing the apples or wiping the apples would remove practically all of the lead arsenate from them. Paring the apples would remove it entirely.

SUMMARY.

Mid-summer spraying with lead arsenate is an effective way of combatting the brown-tail moth. The spraying should be thorough and applied about the time the eggs are hatching.

The amount of arsenic or of lead that will remain at harvest upon the apples that are sprayed in mid-summer with arsenate of lead is so slight as to have no practical bearing.

